



Armed Forces College of Medicine AFCM



Development of Musculoskeletal System (Limbs)

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

- 1. Describe the onset and stages of limb development.**
- 2. Predict the congenital anomalies of limbs and their possible causes.**

Lecture Plan



- 1. Part 1 (5 min) Introduction**
- 2. Part 2 (40 min) Main lecture**
- 3. Part 3 (5 min) Summary**

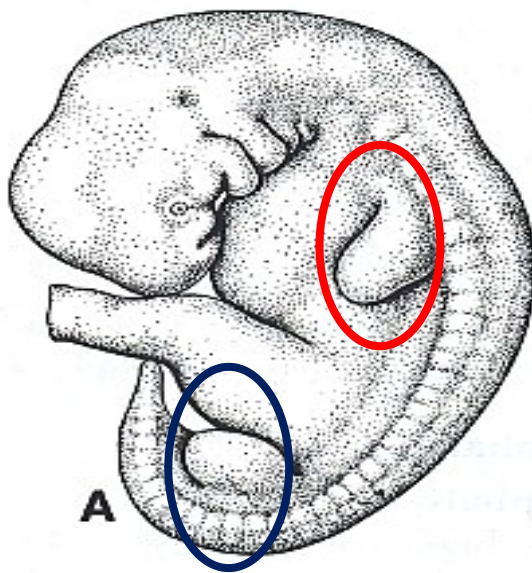
Key Points



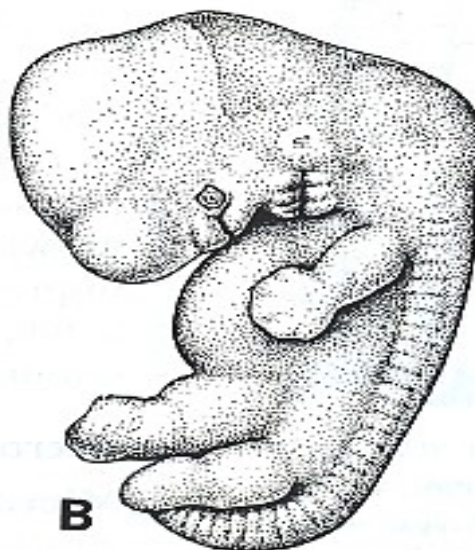
- 1. The onset and stages of limb development**
- 2. The congenital anomalies of limbs and their possible causes**

Development of Musculoskeletal System

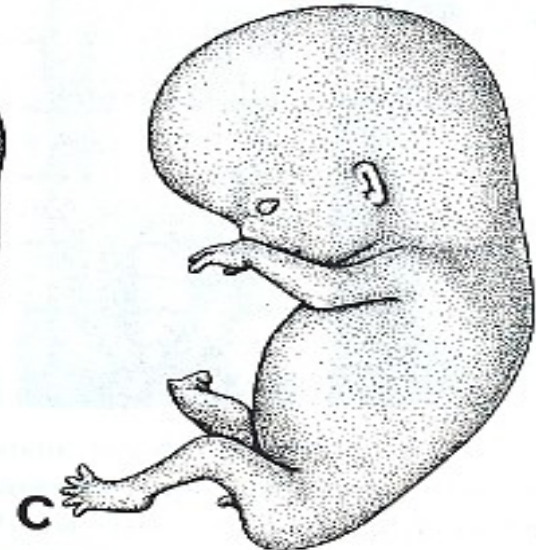
- The limbs develop totally during the **2nd month** (i.e., 5-8 wks).
- At the end of the **fourth week** of development, four paddle-like limb buds develop from the ventrolateral body wall.



5 weeks



6 weeks

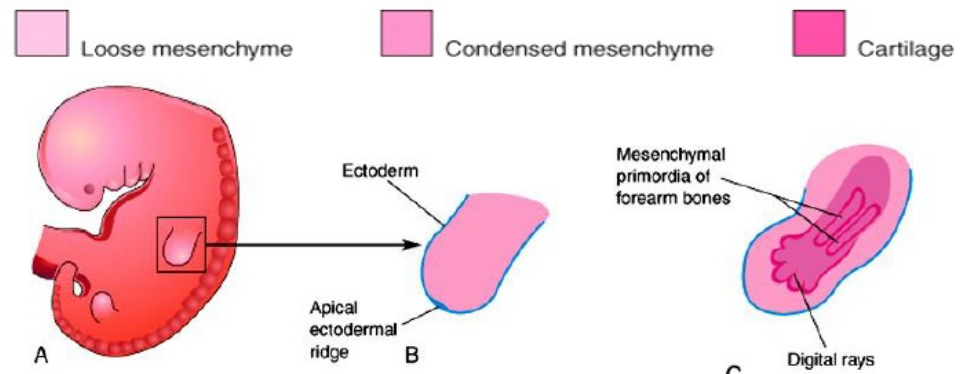


8 weeks

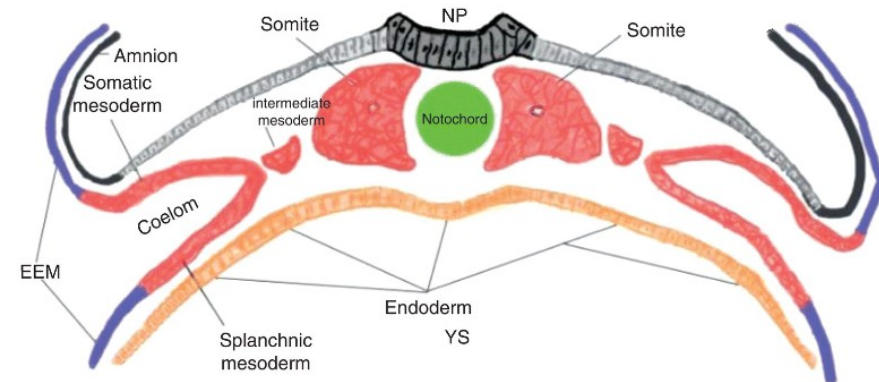
Langman: Medical embryology; 14th edition

Development of the Limbs

- The upper limb bud appears **2 days** before the lower limb bud (i.e., days 28 and 30 successively).
- Each limb bud consists of a mass of **mesenchyme** (mesoderm) covered by **ectoderm**.
- The mesenchyme (mesoderm) of the limb buds is derived from the **somatic layer** of the **lateral plate mesoderm** that will form bones and connective tissue of the limbs.



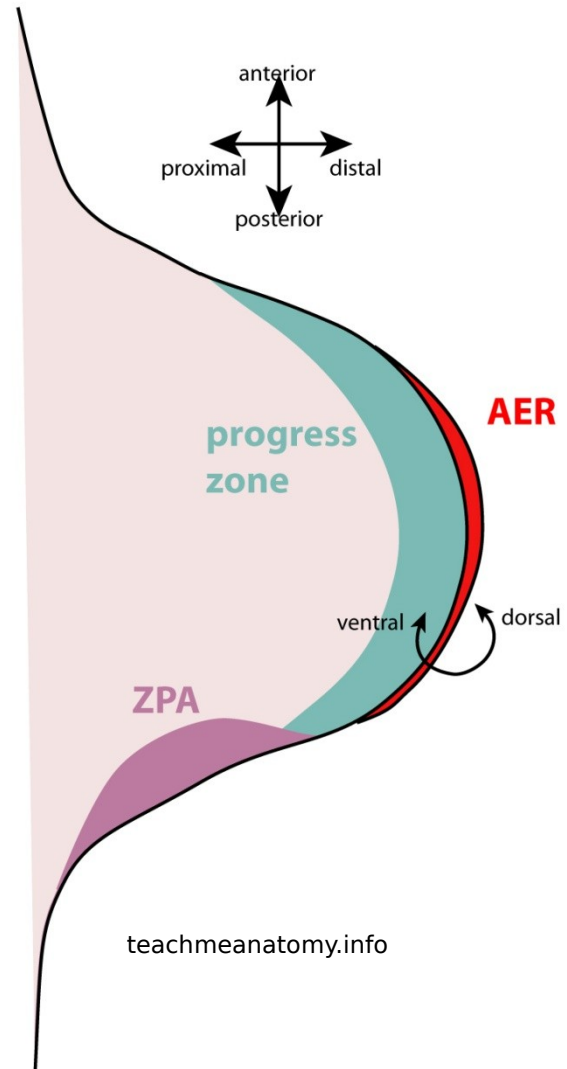
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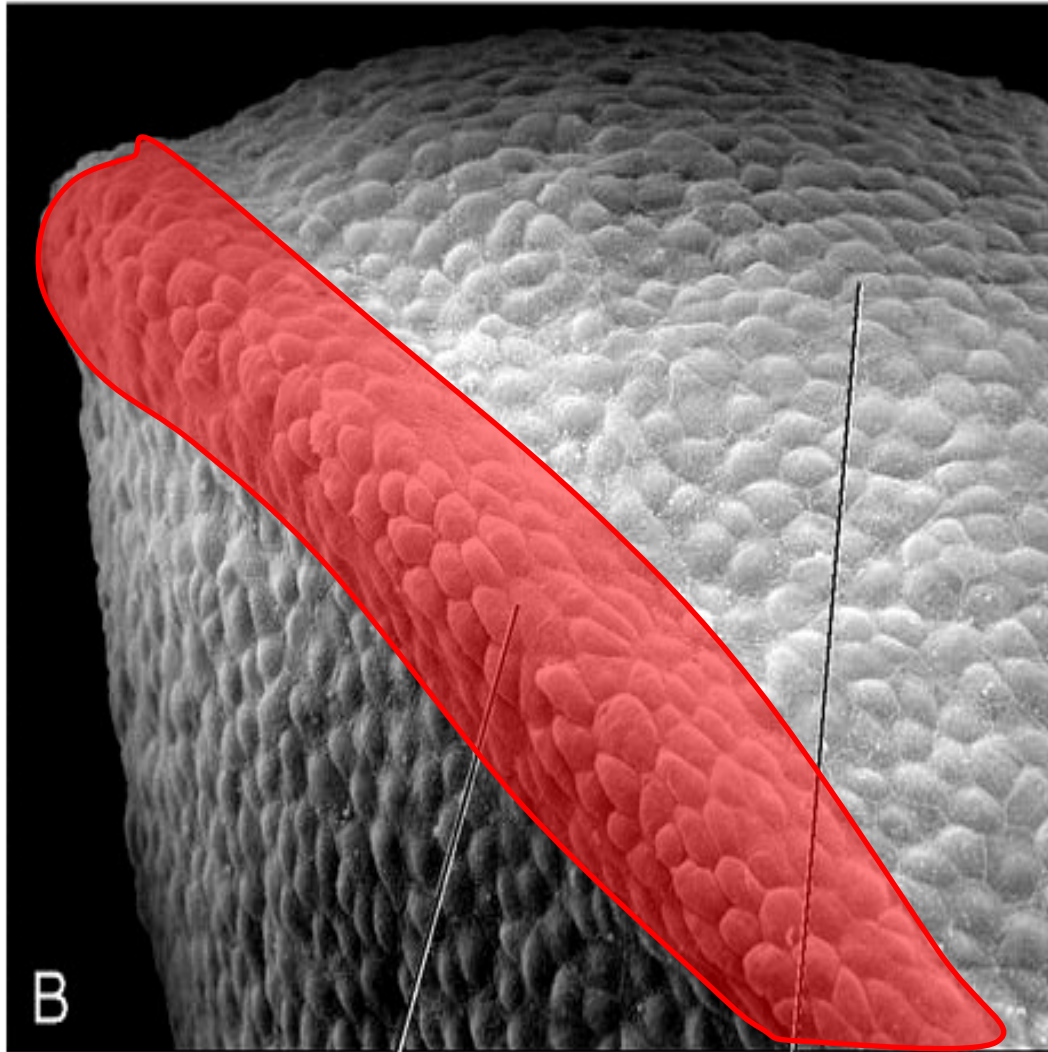
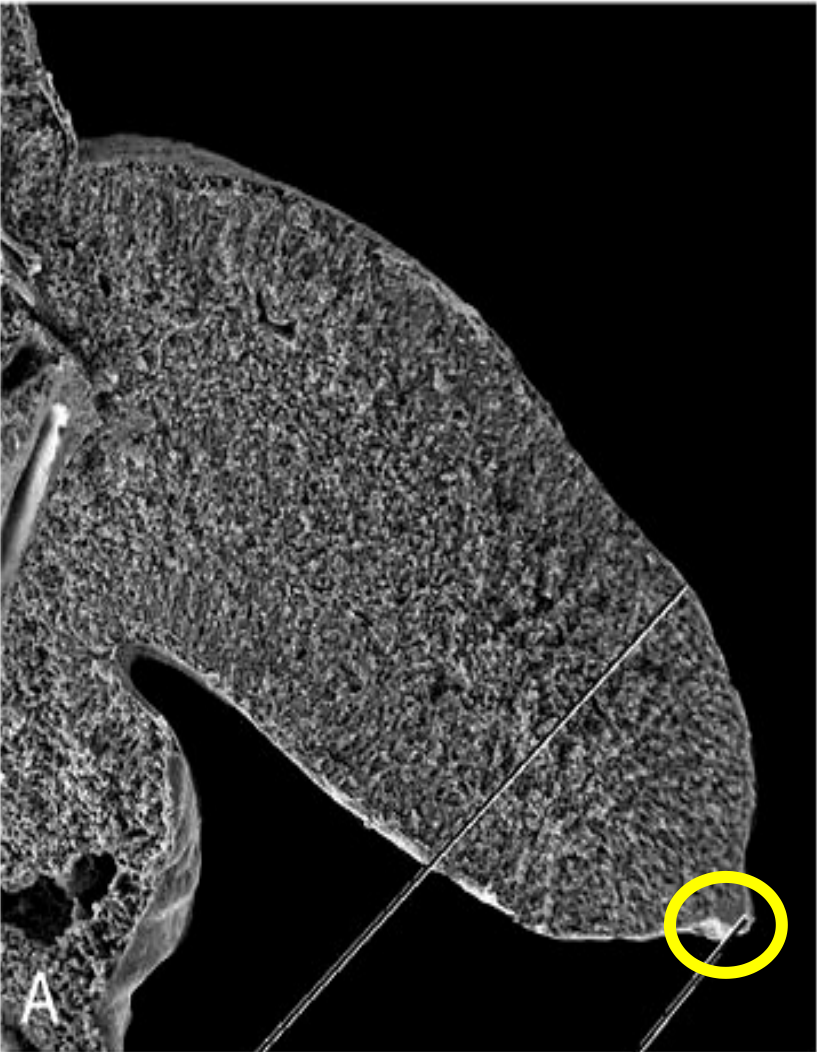


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Development of the Limbs

- Ectoderm at the distal border of the limb thickens and forms the **apical ectodermal ridge (AER)**.
- **This ridge** exerts an **inductive influence** on adjacent mesenchyme, causing it to remain as a population of **undifferentiated, rapidly proliferating cells**, the **progress zone**.
- As the limb grows, cells farther from the influence of the **AER** **begin to differentiate into cartilage and muscle**.





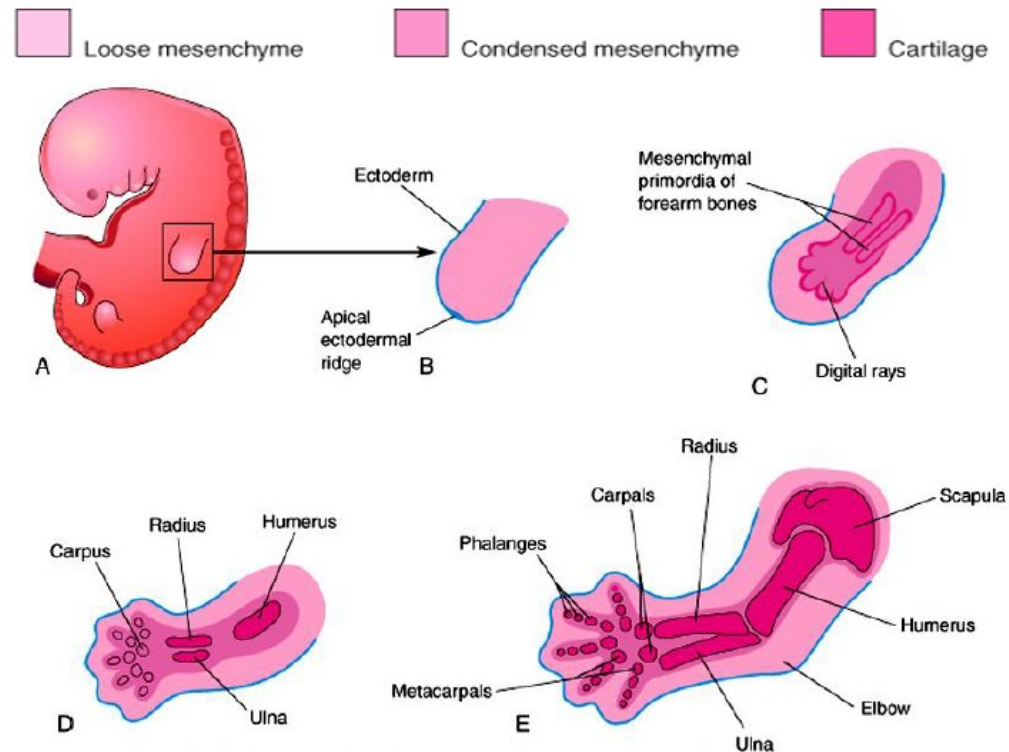
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Ectoderm
Apical ectodermal ridge
(AER)

Apical ectodermal ridge
(AER)
Ectoderm

Development of the Limbs

- In **6-week-old** embryos the terminal portion of the limb buds becomes **flattened** to form the **handplates** and **footplates** and is separated from the proximal segment by a circular constriction.

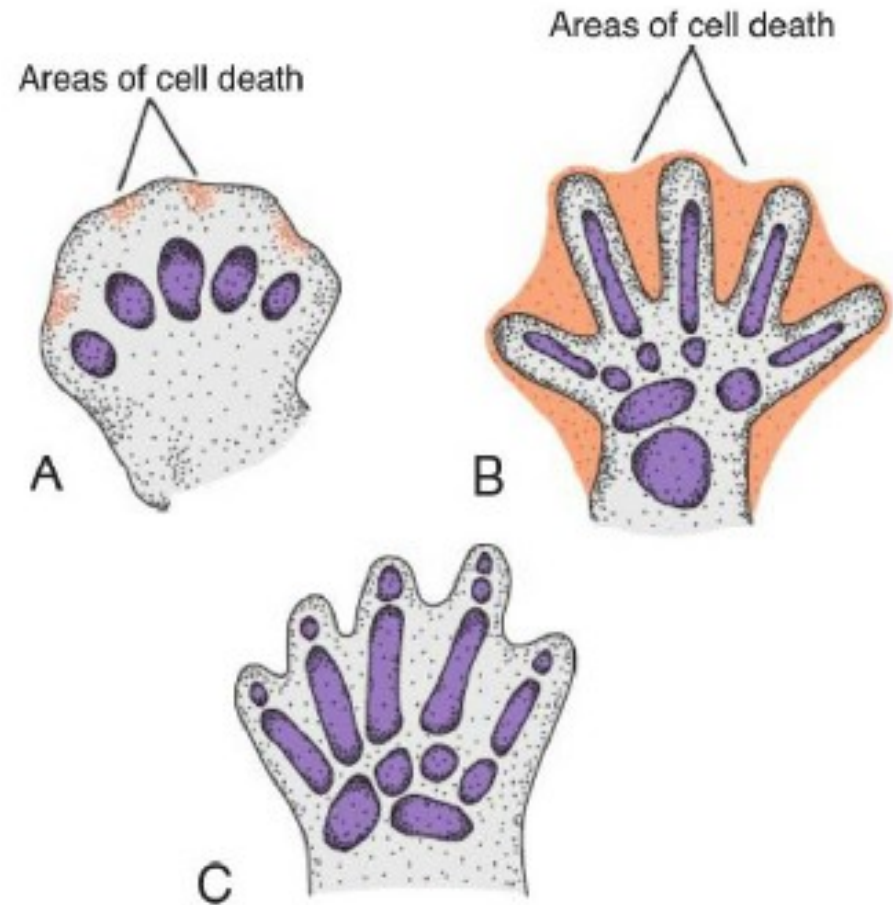


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- Later a **second** **constriction** divides

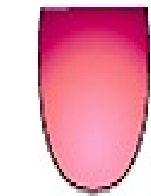
Development of the Limbs

- **Fingers and toes are formed when cell death in the AER separates this ridge into five parts.**
- **Further formation of the digits depends on their continued outgrowth under the influence of the five segments of ridge ectoderm, condensation of the mesenchyme to form cartilaginous digital**



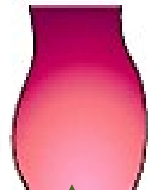
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UPPER
LIMB:



A

Limb buds



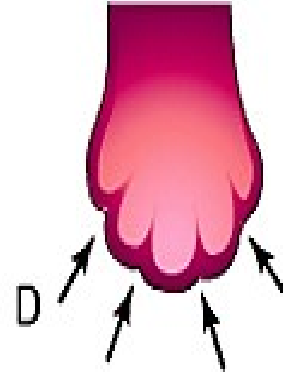
B

Paddle-shaped
hand- and
footplates



C

Digital rays



D

Notches
between
digital rays



E

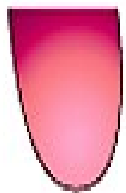
Webbed fingers
and toes



F

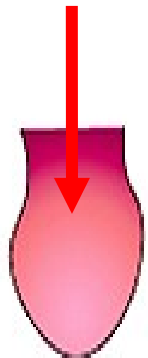
Separate digits

LOWER
LIMB:

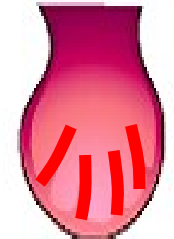


G

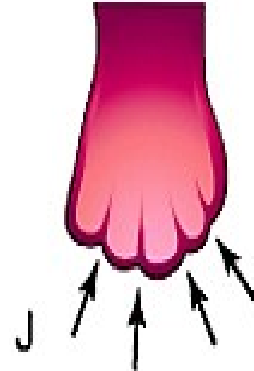
New Five Year Program



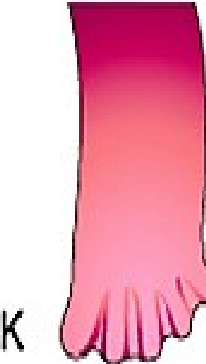
H



I



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K



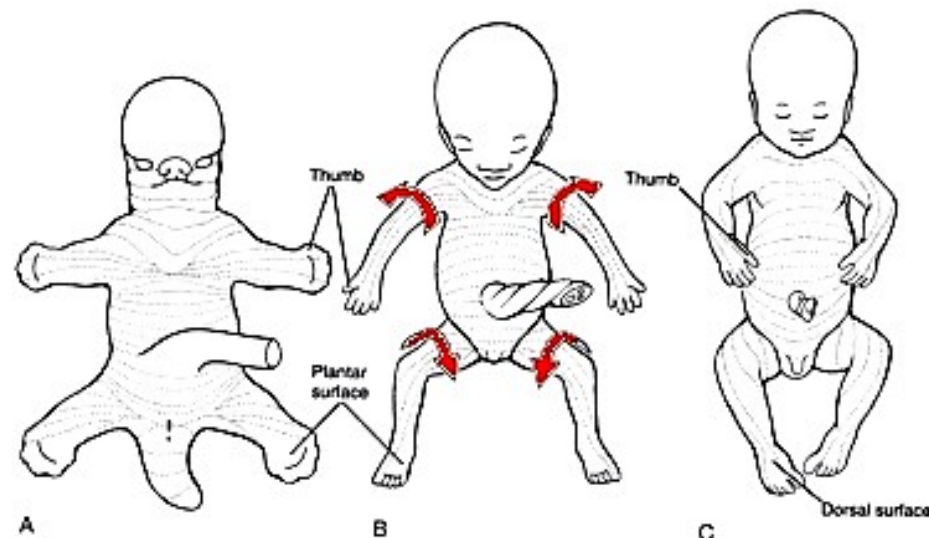
L

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Musculoskeletal System

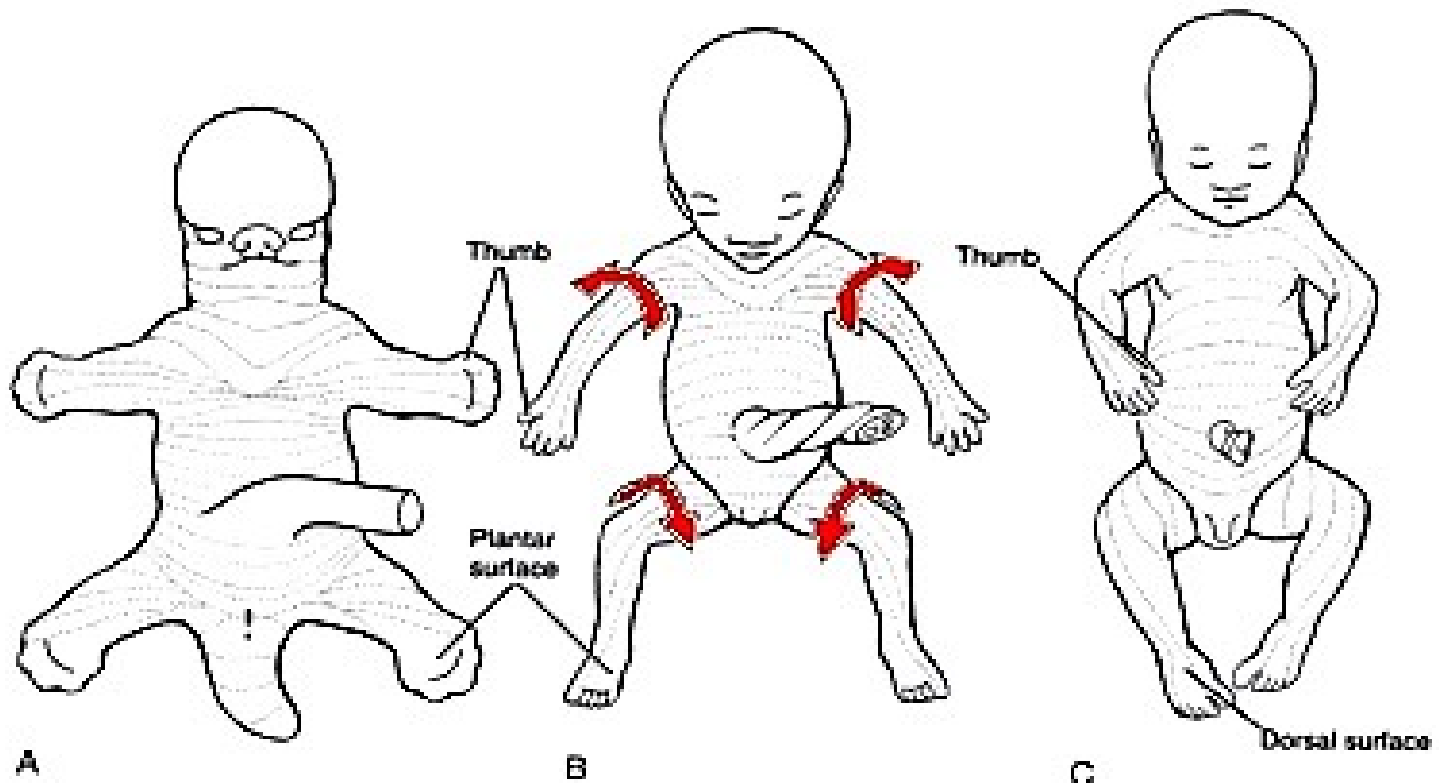
Development of the Limbs

- Development of the upper and lower limbs is similar **except** that morphogenesis of the lower limb is 1-2 days behind that of the upper limb.
- Also, during the **seventh week** of gestation the limbs rotate in **opposite** directions.
- The upper limb rotates **90° laterally**, so that the **extensor** muscles lie on the **lateral** and **posterior** surface and the **thumbs** lie **laterally**, whereas the lower limb rotates approximately **90° medially**, placing the **extensor** muscles on the **anterior** surface and the **big toe medially**.



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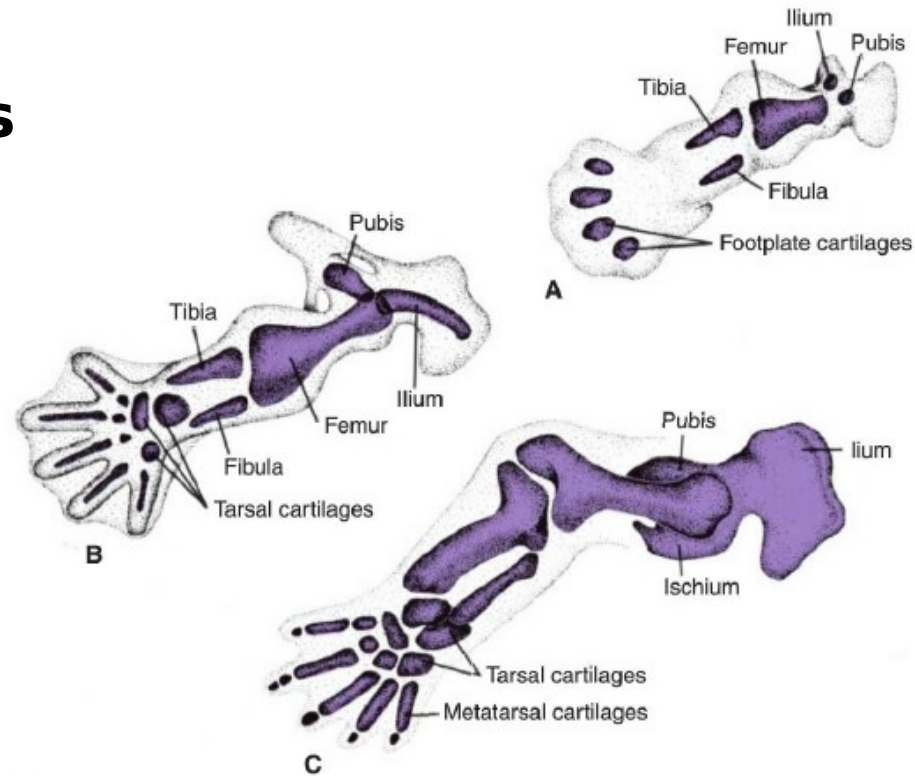
Rotation of limbs



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Development of the Limbs

- While the **external shape** is being established, **mesenchyme** in the buds begin to **condense** and these cells differentiate into **chondrocytes**.
- By the **sixth week** of development, **the first hyaline cartilage models**, foreshadowing the bones of the extremities, are formed by these chondrocytes.

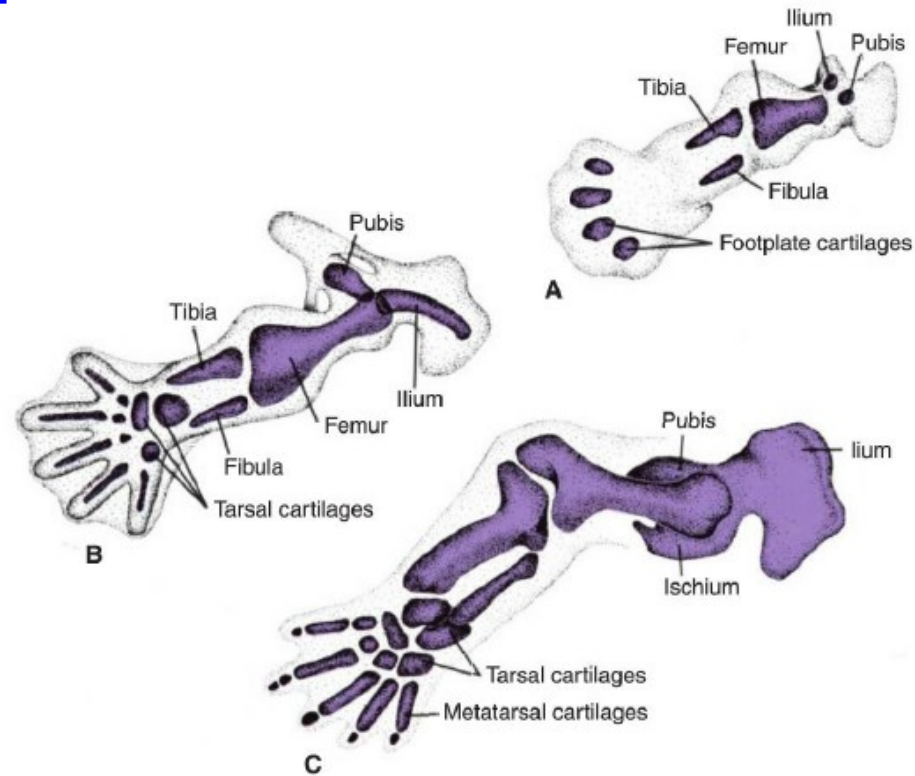


Langman: Medical embryology; 14th edition

Development of the Limbs

▪ Muscles of the limbs:

- Those of **girdles** develop (with the trunk) from **myotomes of somites**.
- The **remaining muscles of the limbs** develop from the **lateral plate somatic mesoderm**.



Langman: Medical embryology; 14th edition

Development of the Limbs

- **3rd month** ⇒ **Nails appear.**
- **4th month** ⇒ **Fingerprints develop.**
- **The muscles become strong and the baby starts to kick against the uterine wall. The mother starts to feel the movements called quickening.**



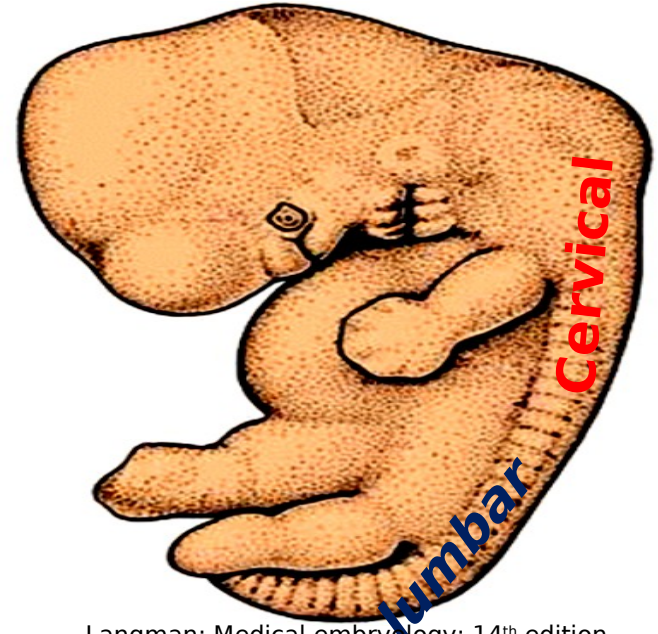
Development of the Limbs

Lower limb buds	Upper limb buds	
.medially 90°	.laterally 90°	Rotation
-The flexors posterior -The extensors anterior	-The flexors anterior -The extensors posterior	Results: 1. Muscles:
-The knee joint points forwards.	-The elbow joint points backwards.	.2 :Joints
-The tibia medial -The fibula lateral	-The radius lateral -The ulna medial	.3 :Bones
-The big toe medial	-The thumb lateral	.4 :Digits

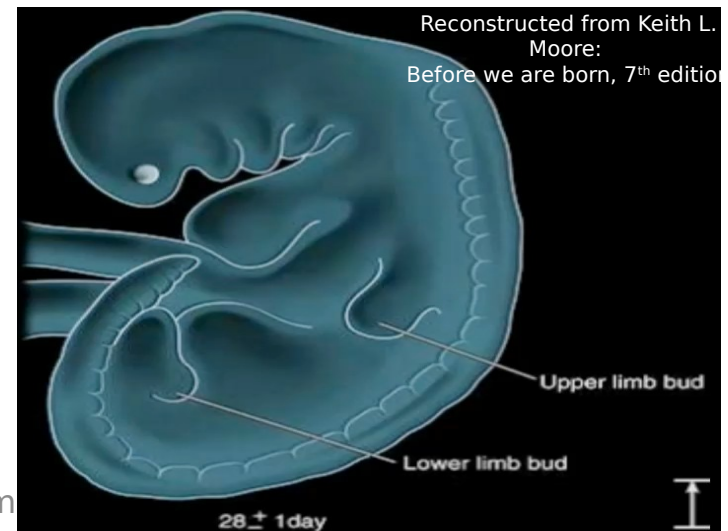
Development of the Limbs

□ Innervation of the limb buds:

- The **upper limb buds** develop opposite the **lower cervical segments**, whereas the **lower limb buds** develop opposite the **lumbar and upper sacral segments**.
- A group of ventral rami of spinal nerves supplies the skin and muscles of each bud:
 1. The upper limb bud is supplied by ventral rami from C5 to T1 [brachial plexus].
 2. The lower limb bud is supplied by ventral rami from L 1 to S4 [lumbar and sacral plexuses].

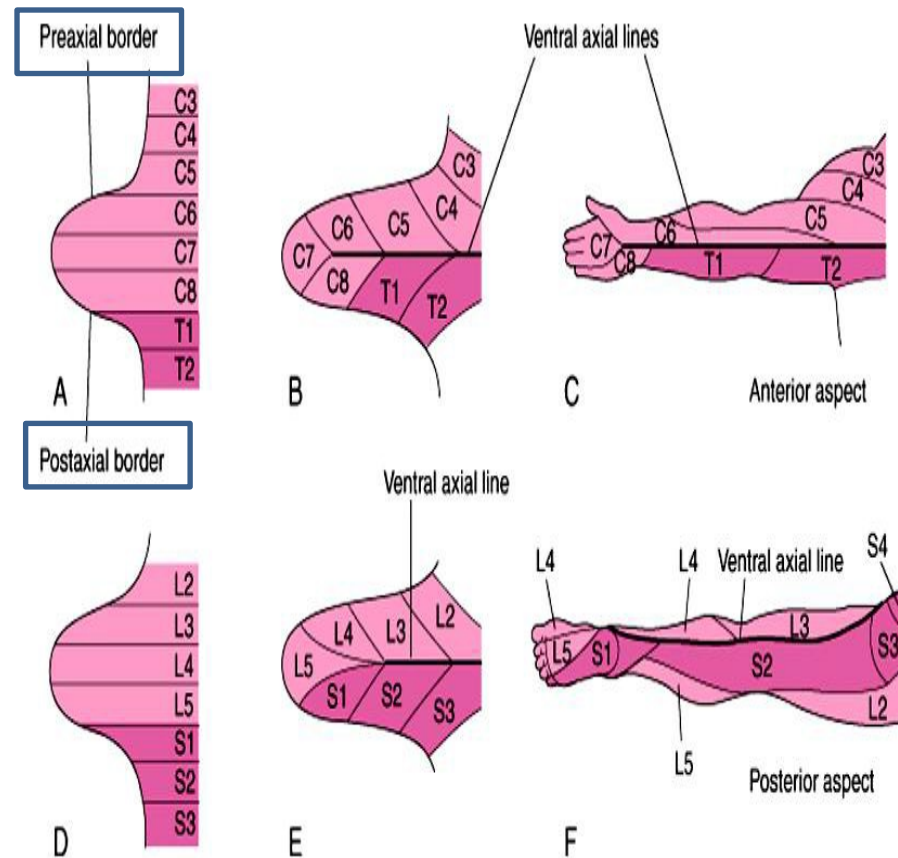


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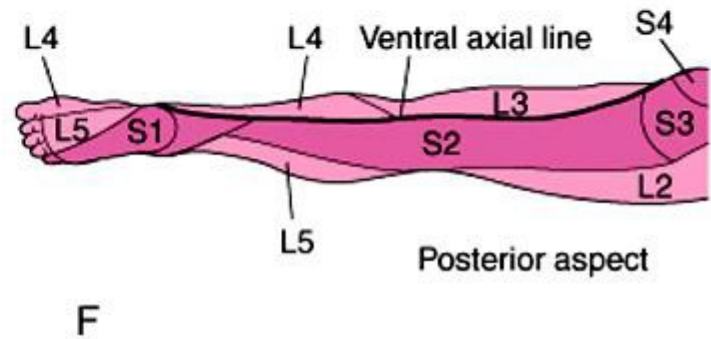
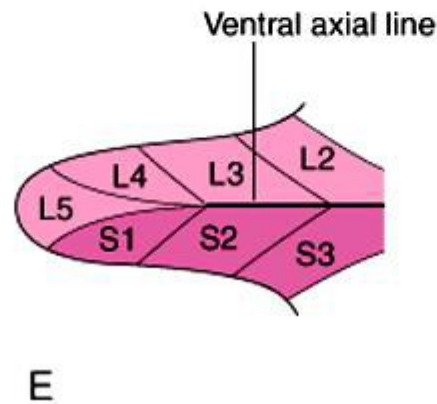
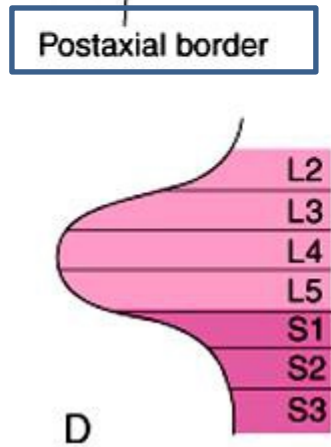
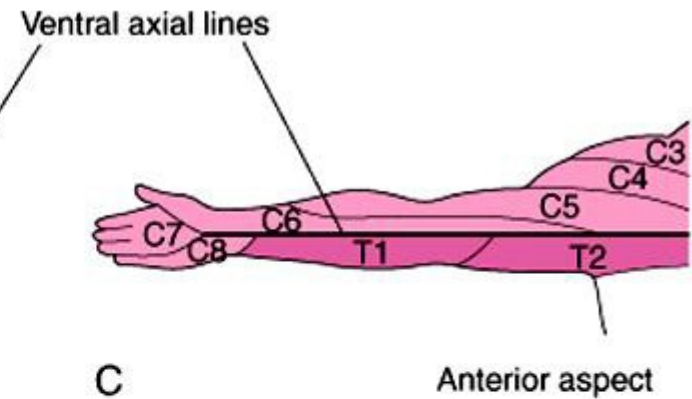
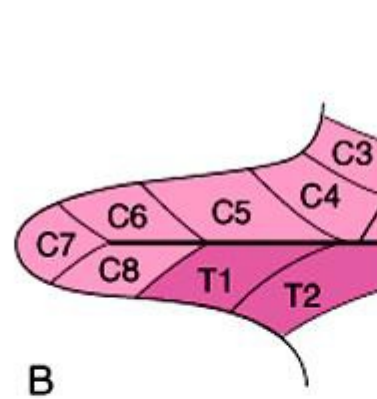
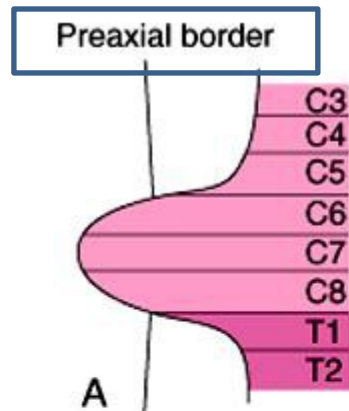


Development of the Limbs

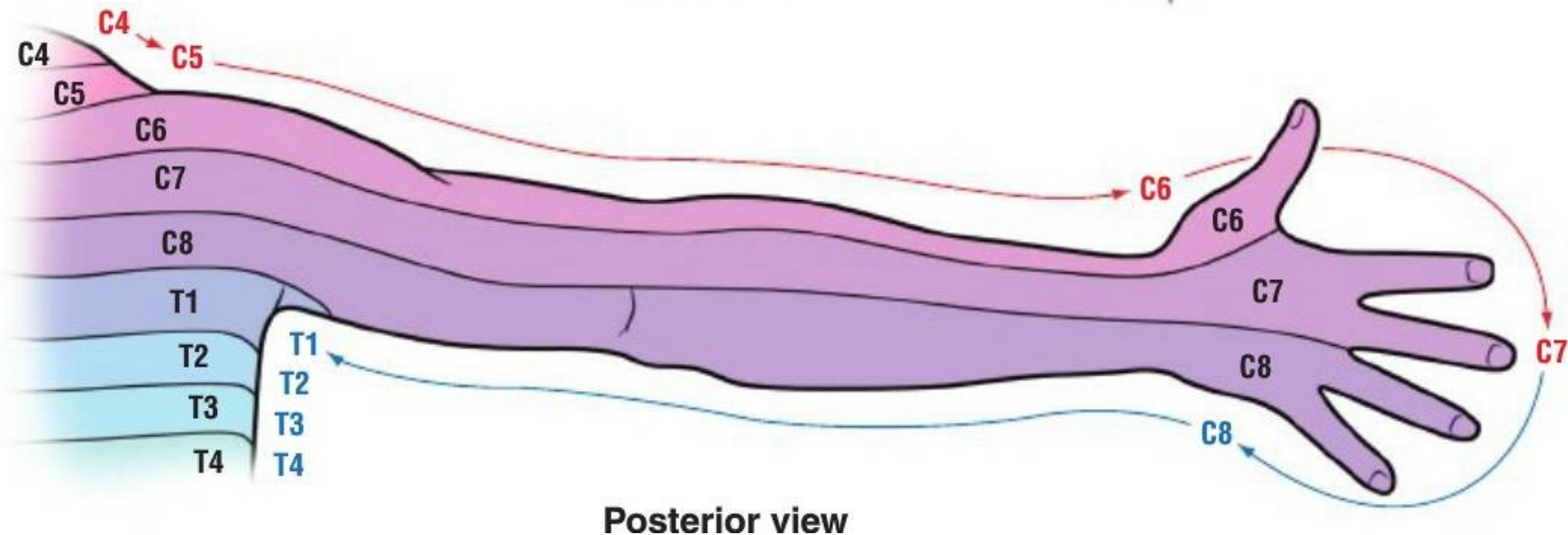
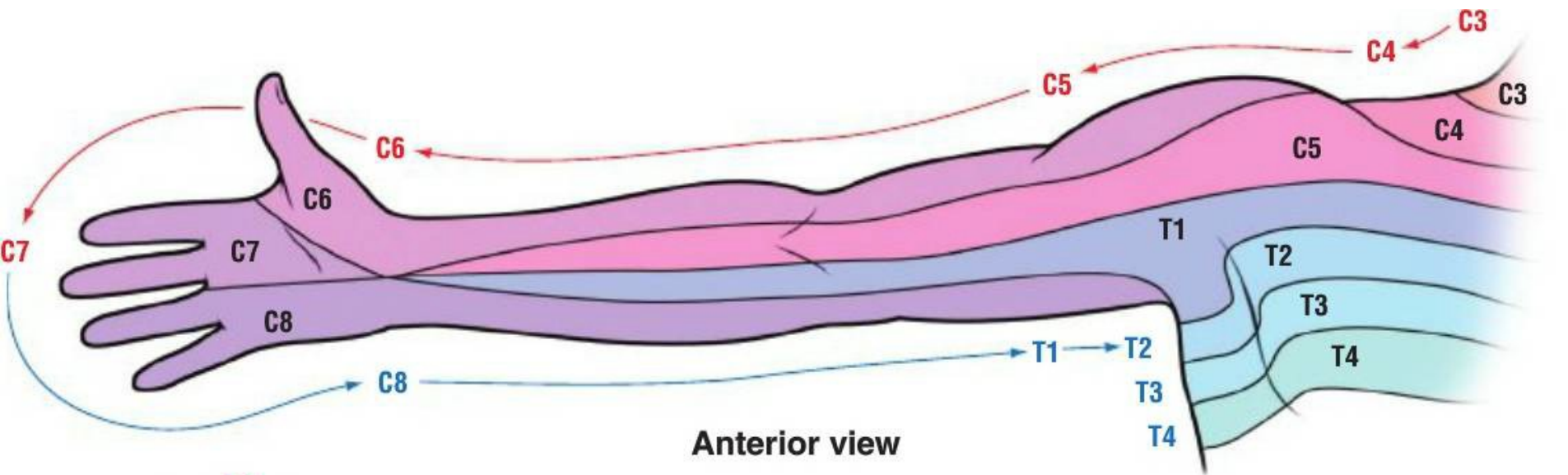
- **A dermatome** is a skin area supplied by a single spinal nerve.
- As the buds grow, the **spinal nerves are elongated**.
- As a result, the cranial dermatomes (e.g. C 4,5,6 in the case of the UL) occupy the **preaxial border** whereas the caudal dermatomes (e.g. C 8 & T 1,2) occupy the **postaxial border**.
- The central dermatome (C 7) becomes buried in the proximal part of the limb but **reappears distally** (e.g. in the hand).



Keith L. Moore: Before we are born, 7th edition



Keith L. Moore: Before we are born, 7th edition



Development of the Limbs

❑ Anomalies of the development of the limbs:

1. **Amelia:** Complete absence of one or more limbs.
2. **Meromelia:** The limb is represented only by the hand or foot.



Langman: Medical embryology; 14th edition



B
Langman: Medical embryology; 14th edition

Meromelia

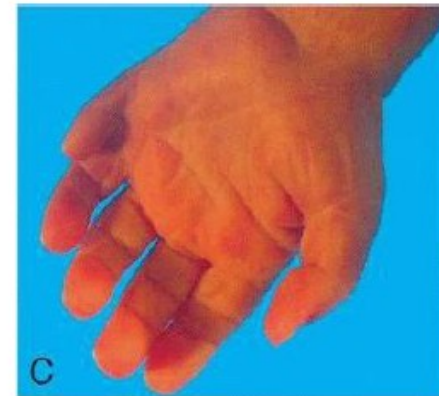
Development of the Limbs

- 3. **Syndactyly:**
Fused one or more digits.
- 4. **Polydactyly:**
Supernumerary digits.

5.



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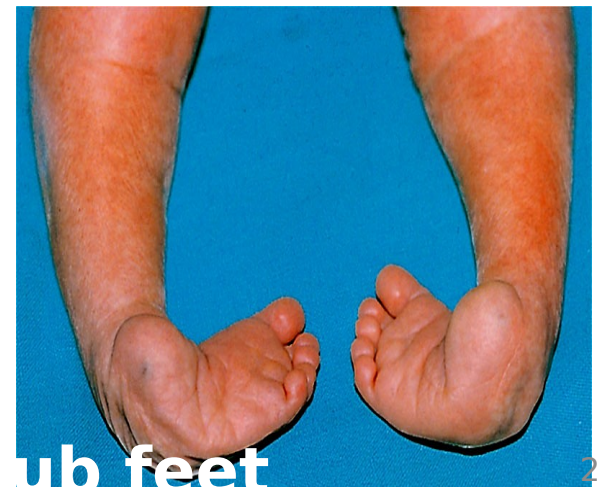
Development of the Limbs

6. **Club foot:** The feet are plantar-flexed and inverted constantly.
7. **Cleft hand or foot [Lobster Claw Deformity]:** One or more middle digit(s) is absent. Thus, the hand (or foot) is divided into two parts. In each part, the digits are fused.



Lobster claw foot

Langman: Medical embryology; 14th edition



Quiz

1. Mention true or false:

- a. Upper limb bud appears 1 week earlier than lower limb bud.**
- b. Forearm flexors develop from lateral plate mesoderm.**
- c. Upper limb bud rotates laterally while lower limb bud rotates medially.**

2. List anomalies of the digits.

Quiz

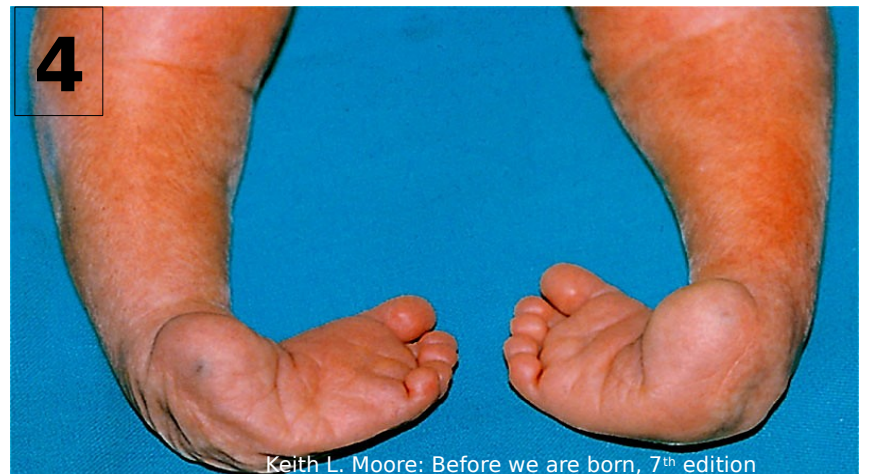
1. Mention true or false:

- a. Upper limb bud appears 1 week earlier than lower limb bud. **F**
- b. Forearm flexors develop from lateral plate mesoderm. **T**
- c. Upper limb bud rotates laterally while lower limb bud rotates medially. **T**

2. List anomalies of the digits.

- **Syndactyly**
- **Polydactyly**
- **Bradydactyly**
- **Cleft hand or foot**

Identify the anomaly



Lecture Summary



- Each limb bud has an outer ectodermal covering and inner mesenchymal (mesodermal) core.
- The ectoderm presents AER which induces the mesenchymal core to proliferate and differentiate.
- Each limb bud develops 2 constrictions, which divide each limb bud into 3 segments.
- Limb buds undergo rotation and adduction; upper limbs rotate 90 degrees laterally, while lower limbs rotate 90 degrees medially.
- A group of ventral rami of spinal nerves supplies the skin and muscles of each bud.
- Anomalies of the development of the limbs are: amelia, meromelia, syndactyly, polydactyly, bradydacty, club foot and cleft hand or foot.

Suggested Textbooks

- 1. Keith L. Moore: Before we are born, essentials of embryology and birth defects; 7th edition.**
- 2. Langman: Medical embryology; 14th edition.**
- 3. Web site: www.studentconsult.com**

Thank you